Quantum Institute Workshop

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Nanocrystal Quantum Dots and Quantum Technologies

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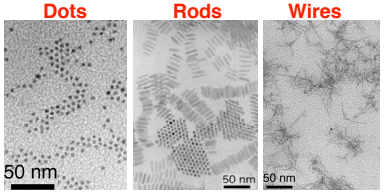
Our Materials

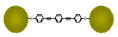
Semiconductor Nanocrystal Quantum Dots (NQDs)

Dots Rods Wires

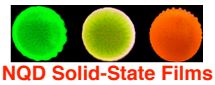


(1.2:1) (4.4:1) (50:1)

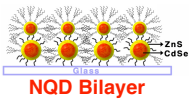
- Controlled compositions (e.g., II-VI, III-V)
- Controlled sizes and shapes
- Controlled assembly



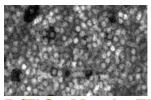
NQD "Molecule" (dimer)



NQD Solid-State Films



NQD Bilayer

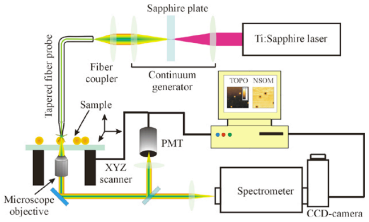


NQD/TiO_2 Matrix Film

Our Tools

Capability to *probe and manipulate* nano-scale objects on ultrafast timescales

- Femtosecond near-field optical spectroscopy (spatial resolution <100 nm combined with time resolution of 200 fs!)



- Single-dot spectroscopy and coherent manipulation (cryogenic temperatures and potentially magnetic field)
- Femtosecond transient absorption and photoluminescence spectroscopies

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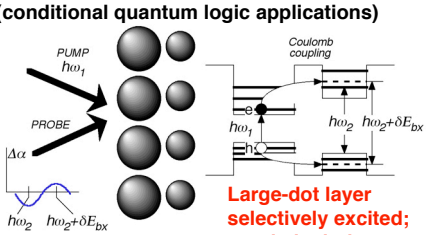
Apply Quantum-Control Ideas Developed for Atomic Gaseous Systems to the Solid State Using NQDs

NQD Features Useful for QI

- Very strong exciton-exciton interactions (conditional quantum logic applications)



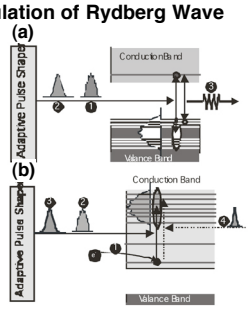
Large-dot layer selectively excited; proximity induces biexciton shift (δE_{bx}) in small-dot layer

- Widely separated "atomic-like" states that, in contrast to atoms, are widely tunable by composition/size/shape control
- Relatively slow dephasing (electron-phonon interactions are much weaker than in the bulk)
- NQD structures are easily scalable

Implementation

- Coherent manipulation of Rydberg Wave Packets

"Rydberg-like" wave packets in "atomic-like" NQD electronic states



- Conditional quantum logic using NQD bi-layers and eventually single dimers (e.g., controlled-NOT operation; see figure)
- NQDs coupled to a high-Q microcavity: Communication between NQDs via a microcavity mode
- Entangled exciton states in a single dot
- NQD as a single-photon source and NQD biexcitons as a source of entangled photons

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Presenter: Victor Klimov